REMARKS

Favorable reconsideration of this application, as presently amended and in light of the following discussion, is respectfully requested.

Claims 1-10 are pending. Claims 7-10 having been withdrawn from consideration in response to Applicants' election, and Claims 1, 7, and 8 having been amended by way of the present amendment.

In the outstanding Official Action, Claims 1-6 were rejected as being unpatentable over Kawarada et al (U.S. Pat. No. 5,420,879).

The present invention relates to a diamond semiconductor exhibiting a non-linear exciton light-emission intensity characteristic, and as such is suitable for diamond semiconductor light-emitting devices. As described in the specification, a diamond semiconductor exhibiting the nonlinear light-emission intensity characteristic can be fabricated using a microwave plasma chemical vapor deposition (CVD) method in which a raw gas having a concentration of the methane gas in hydrogen being for example 0.016%, 0.025%, 0.5%, 1.0% and 2.0% is used.[2] Applicants disclose that:

> ...the diamond semiconductor of this invention demonstrates an exciton light-emission intensity characteristic that varies non-linearly, and therefore it is able to emit ultraviolet light extremely efficiently. Further, since this invention uses a diamond semiconductor with high quality sufficient to emit ultraviolet light at a room temperature with energy injection, the threshold of the nonlinear optical characteristic can be made low depending on the level of high quality. Thus, it is possible to emit ultraviolet light with even greater efficiency.[3]

Further, Applicants disclose in the specification that the discovery of diamond having a non-linear optical characteristic was not known prior to the present invention.[4]

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[2]Specification, numbered paragraphs [0031] and [0032].

[3]Id., page 3, numbered paragraph [0012].

[4]Id., page 1, numbered paragraph [005].

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Indeed, the Official Action acknowledges that Kawarada et al do not teach an exciton light-emission characteristic that varies non-linearly.[5] However, the Official Action asserts that it would be obvious to modify Kawarda et al's device to a particular application, and notes that setting forth a property inherent in an otherwise old composition does not differentiate.[6] Yet, as noted above, diamond having a non-linear exciton light-emission intensity characteristic was not known prior to the present invention, and thus would not be expected to be an inherent property.

M.P.E.P. § 2112 states that, in relying upon the theory of inherency, the examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic necessarily flows from the teaching of the applied prior art. However, in the present case, the applied prior art teaches away from the claimed non-linear exciton light-emission intensity characteristic. For example, Kawarada et al disclose that both natural diamond crystal having few impurities or an artificial diamond crystal can exhibit exciton light-emission.[7] Further, Kawarada et al disclose, with regard to vapor deposited diamond, that:

> In a polycrystalline diamond, the ***crystal grain boundary*** thereof and the ends of the crystal particles become the center of the recombination ***which deactivates the excitons***. Therefore, the diamond crystal may be preferably a single crystal and, when the diamond crystal is a polycrystalline one, it is important that each of the crystal grains is as large as possible. The size of the single crystal and the size of each of the crystal grains of the polycrystalline diamond must be at least 1 μm or more. If the size is less than 1 μm, then there is inconveniently increased the number of the excitons that are deactivated in the grain boundary.[8] [emphasis added]

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[5]Official Action, page 3, lines 3-4.

[6]Id., page 3, lines 5-9.

[7]Kawarada et al, col. 2, lines 51-57.

[8]Id., col. 3, lines 37-49.

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Thus, the teaching of Kawarada et al suggests that single crystal diamond having few impurities and large grain size polycrystalline diamond are suitable for exciton-based light emission. However, the absence of a non-linear exciton light-emission intensity characteristic in Kawarada et al, as acknowledged in the Official Action, suggests that diamond does not inherently show non-linear exciton light-emission. Furthermore, the teaching in Kawarada et al that crystal grain boundaries deactivate excitons (hence reducing the population of excitons in the diamond semiconductor) teaches away from a chemical vapor deposited diamond semiconductor (known in the art to be typically polycrystalline) having a non-linear exciton light-emission intensity characteristic.

Moreover, since the diamond semiconductor of the present invention exhibits a non-linear exciton light-emission intensity characteristic, light-emitting devices can be fabricated with the diamond semiconductor of the present invention even without the reflectors disclosed in the light-emitting devices of Kawarada et al.[9] Without the reflectors, the size of light-emitting devices made with the diamond semiconductor of the present invention can be reduced in size in comparison to the light-emitting devices of Kawarada et al.

M.P.E.P. § 2143 states that all the claim limitations must be taught or suggested by the prior art to establish *prima facie* obviousness. With Kawarada et al not teaching (indeed teaching away from) diamond having a non-linear exciton light-emission intensity characteristic and with the Official Action not providing any basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic necessarily flows from the teaching of Kawarada et al, it is respectfully submitted that Claim 1 and the claims dependent therefrom patentably define over the applied prior art.

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[9]Kawarada et al, see Figure 1, reflectors 3 and 4.

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Consequently, in view of the present amendment and in light of the above discussions, the outstanding grounds for rejection are believed to have been overcome. The application as amended herewith is believed to be in condition for formal allowance. An early and favorable action to that effect is respectfully requested.

Finally, the attention of the Patent Office is directed to the change of address of Applicants' representative, effective January 6, 2003:

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Please direct all future communication to this new address.

Respectfully submitted,

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Marked-Up Copy
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Amendment Filed on: 5/5/2003

IN THE CLAIMS

Please amend Claims 1, 7 and 8 as follows:

1. (Amended) A diamond [Diamond] semiconductor having an exciton light-emission intensity characteristic that varies nonlinearly, said diamond semiconductor being fabricated using a raw gas including a methane gas and a hydrogen gas in a microwave plasma chemical vapor deposition method, in which the methane gas has a concentration of not more than 2.0%.

7. (Amended) A diamond semiconductor light-emitting device comprising:

an n-type diamond semiconductor layer[,];

a p-type diamond semiconductor layer formed while maintaining a predetermined interval between it and said n-type diamond semiconductor layer[,]; and

a high-quality undoped diamond semiconductor layer sandwiched between said n-type diamond semiconductor layer and said p-type diamond semiconductor layer and fabricated using a raw gas including a methane gas and a hydrogen gas in a microwave plasma chemical vapor deposition method, in which the methane gas has a concentration of not more than 2.0%,

wherein an exciton light emission that varies nonlinearly according to a current value is output from said undoped diamond semiconductor layer when current is injected to respective electrodes formed on said n-type and p-type diamond semiconductor layers.

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8. (Amended) A diamond semiconductor light-emitting device comprising:

a high-quality n-type diamond semiconductor layer fabricated using a raw gas including a methane gas and a hydrogen gas in a microwave plasma chemical vapor deposition method, in which the methane gas has a concentration of not more than 2.0%[,];

a high-quality p-type diamond semiconductor layer formed in contact with said n-type diamond semiconductor layer and fabricated using a raw gas including a methane gas and a hydrogen gas in a microwave plasma chemical vapor deposition method, in which the methane gas has a concentration of not more than 2.0%[,]; and

an activation region layer formed in an interface between said n-type diamond semiconductor layer and said p- type diamond semiconductor layer,

wherein an exciton light emission that varies nonlinearly according to a current value is output from the activation region layer when current is injected to respective electrodes formed on said n-type and p-type diamond semiconductor layers.

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